Traces of Environmental Chemicals in the Human Body: Are They a Risk to Health?: Revised Edition [2/05/03]

Executive Summary

What are trace levels of environmental chemicals?

What kinds of chemicals are found at trace levels in humans?

How do we measure trace levels of xenobiotics in humans?

A. Fates of absorbed xenobiotics
B. Implications of fates for measuring trace levels in human fluids and tissues
C. Using monitoring of intake to estimate trace levels

What are the trends in trace levels of environmental chemicals

A. Trends based on food data
B. Trends based on human tissue and fluid analyses

What can we learn from these trend data?

What is the human health significance of these trace levels?

A. Establishing links between environmental exposures and health effects
B. Applying these approaches to trace chemicals

Summary and Conclusions

References

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Executive Summary

Because living organisms, including humans, are part of the environment they reflect what is in their surroundings. Traces of a large variety of both natural and made-made compounds can be found in the tissues and fluids of humans as a result of exposure to these compounds in air, soil, water and food.

As analytical capabilities have improved, it has become possible to detect ever increasing numbers of synthetic environmental chemicals at lower and lower concentrations. It has also become clear that because of the persistent nature of some of these chemicals, they are likely to remain in humans for some time to come. Thus, concerns about the possible health impacts on these chemicals will continue.

To address these concerns, it is important to understand what the trends are in the levels of these trace contaminants and what the health impacts may be from the levels that are being detected in human fluids and tissues.

Evidence from analysis of foods and from direct measurements of fluids and tissues reveals that the levels of the synthetic contaminants have decreased greatly over time. Studies of lead and persistent organochlorine compounds, such as DDT and dieldrin, clearly document this trend and show a decrease of more than 90% during the last quarter of the 20th century. While the levels have continued to decrease in the last decade the rate of decrease has slowed. In addition, the data reveal that there are some sub-populations that are still exposed to unusually high amounts of these contaminants.

As a result of these large decreases in concentrations, current levels of environmental chemicals in the general population are well below those considered to be associated with adverse effects and thus do not pose a risk to public health. Efforts

to improve environmental health should thus focus on those populations with especially high exposures; e.g., children living in homes with high levels of lead.

What are trace levels of environmental chemicals?

The natural world contains a wide variety of different chemicals that humans may be exposed to through their food, water and air or through lifestyle choices. Many of these natural substances are necessary for human health at low levels; e.g., selenium. (1) Others may have no apparent health benefit and, indeed, may be harmful at levels found in the environment in some locations. For example, toxic levels of arsenic are found naturally in water in some areas of the world. These chemicals can be detected in people through analysis of body fluids and tissues. For example, analysis of the hair of people who drink water containing arsenic provides a measure of the amount of arsenic exposure.

In addition to these naturally occurring substances, a large number of chemicals were introduced into the environment as a result of processes and products developed during the 20th century to improve health, increase agricultural production, and improve the standard of living. Because of the volumes in which they were produced, or their chemical properties; e.g., persistence, or a combination of both, some of these compounds remained in the environment for long periods of time. As a result, humans were exposed to such compounds over long periods of time and evidence of this exposure can be found in human fluids and tissues.

In addition to these environmental chemicals, it is possible to detect a number of other compounds in the human body as the result of the use of consumer products, such as pharmaceuticals and dietary supplements, and from life style choices, such as smoking. Some of these chemicals; e.g., by-products of smoking, are also present in the environment due to other sources so that trace levels of such compounds in the body reflect both types of exposures.

The low levels of these naturally occurring and man-made chemicals in humans are called trace levels in this report. They represent levels that have resulted from general environmental exposure that has occurred around the world; that is, they represent traces of these chemicals in the environment. Higher levels of human exposure that sometimes occurred in people who were involved in the production and use of such chemicals or in people who lived close to sources of high levels of environmental chemicals will not be addressed here.

What kinds of chemicals are found at trace levels in humans?

Chemicals that are foreign to the body are known as “xenobiotics”. Such substances can be either naturally occurring (chemicals that are part of the earth or produced by molds, plants or animals) or man-made (such as drugs, industrial chemicals, pesticides, and power generation by-products). Common routes of exposure to these chemicals found in the environment are inhalation, ingestion and absorption through the skin.

As indicated previously, because of the volume and variety of environmental xenobiotics to which humans are exposed over their lifetimes, it is not surprising that traces of such substances can be found in human fluids and tissues. Indeed, with the great improvements in analytical capabilities during the past twenty-five years traces of more and more xenobiotics have been detected as it has become possible to measure ever smaller amounts of these substances. As a result, public awareness and concern about the possible human health impacts of such trace levels has grown.

While the numbers of xenobiotics that have been detected is large, the greatest concern has been focused on a small subset of these compounds that are persistent in the environment. Persistent chemicals are of most concern since their longevity in the environment can lead to continuous, chronic human exposures and, in some cases, to continually increasing levels in human fluids and tissues.

Examples of such persistent chemicals include large organic molecules such as DDT, Dioxins and PCBs as well as metals and their compounds; for example, lead and methyl mercury. While actions have been taken over a number of years to reduce the introduction of such compounds into the environment, it is expected that their persistence will lead to exposures for some time and so trace levels will continue to be found in humans. Thus, it is important to understand the significance, if any, of such trace levels for human health.

How do we determine trace levels of xenobiotics in humans?

A. Fates of absorbed xenobiotics

To understand the methods available for detecting trace levels of environmental xenobiotics, it is important to appreciate what happens in the human body when exposure to such chemicals occurs. The human body handles trace chemicals in numerous ways. However, in general, the first step is absorption of the chemical into the blood where it can be transported freely throughout the body and distributed to various tissues in the body.

After absorption and distribution, the chemical may have three fates: it may be stored in the body, it may be excreted from the body, or it may interact with the body to cause changes that may be beneficial or adverse. The chemical may be stored in a variety of places in the body depending of its characteristics. For example, lipophilic (fat loving) molecules such as DDT dissolve in and are stored largely in fat. Lead, on the other hand, is stored mainly in bone. Mercury may be found in hair and fingernails. Levels of chemicals that are stored in the body tend to increase over time as long as exposure continues and the rate of accumulation exceeds the rate of excretion.

Depending on its characteristics, a chemical may remain in the body for varying amounts of time before it is excreted. Some chemicals are very rapidly

excreted - within a day or two - so they do not stay in the body long. Unless exposures are repeated frequently, or unless assessments are made immediately after exposure, measured levels of such chemicals in the body are generally quite low and often non-detectible.

Chemicals that interact with the body may cause a wide variety of changes. These can range from small alterations in the amounts of essential chemicals, such as enzymes, that the body normally produces to fundamental changes in the functioning of organs. According to the fundamental principle of toxicology whether or not any effect will occur depends on the dose and it is quite possible that effects seen at high doses in laboratory experiments will not occur at the trace levels seen in humans.

Often, after xenobiotics are absorbed by the body they are changed into other compounds by a process called metabolism. The products of metabolism (metabolites) may undergo the same fates as the compound originally absorbed - storage, excretion or interaction. For example, acetosalicylic acid (aspirin) is broken down into salicylic acid and acetic acid in the body. While each of these metabolites may share the same fates as the original compound, the rates and extent of storage, excretion or interaction will be different.

Because metabolism is often incomplete, traces of both the absorbed xenobiotic and its metabolites may be found in human fluids and tissues. How much of an absorbed chemical is metabolized and how much remains unchanged generally depends on dose. This is one reason that caution must be used in applying the results of high dose toxicity studies to trace level exposures.

B. Implications of fates for determination of trace levels

Because of the varying fates of chemicals in the human body, a number of different techniques must be used to detect their presence. For example, if a chemical

is stored in fat, analysis of samples of fat can be used to detect and quantify the levels in an individual. In nursing mothers, such compounds may also be measured in breast milk since these compounds are associated with milk fat.

Taking samples of body fat is an invasive procedure with some medical risk so it is not employed often. However, it is possible to take advantage of the fact that not all of the xenobiotic moves to the fat; a portion of it stays in the blood where it may be detected using a routine blood sample. Similarly, levels of chemicals stored in bone or hair may be measured directly in these tissues or through analysis of blood. Chemicals that are not readily stored in the body may be detected as they are excreted; for example, in urine or even in exhaled air.

Because many xenobiotics are metabolized, it is possible that the absorbed chemical will not be present at levels high enough to be measured. In this case, analysis of these metabolites in fluids such as blood and urine must be performed. Xenobiotics and/or their metabolites in body fluids and tissues are known as biomarkers of exposure. Simply stated, this means that their presence is indicative that exposure has occurred. The concentrations of these biomarkers in the body are also reflective of the environmental levels to which the individuals were exposed.

However, the relationship between environmental levels and concentrations of biomarkers may be complicated if exposures can occur from other sources, such as smoking, as well as from environmental contamination. In such cases, it is often difficult to draw conclusions about environmental contaminant levels from analysis of tissue or fluid levels.

For chemicals that interact with the body, a variety of techniques can be used to detect the effects of this interaction. In a simple case, the interaction may influence the levels of chemicals in the blood; e.g. enzymes, and so enzyme level changes can be used as surrogates to indicate that exposure has occurred. Similarly, the interaction may result in changes in excretion patterns of other chemicals that can

be measured in urine. These substances which are neither the absorbed xenobiotic nor its metabolites are known as biomarkers of effect since they are indicative that effects have occurred.

In some cases, the changes detected in the body are so great that they can be said to be indicators of adverse effects in that individual. For example, if the enzyme levels (either increased or decreased) to a point where proper functioning of an organ system is compromised then it is clear that toxicity has occurred. Similarly, if a xenobiotic leads to a significant change (in either function or number) of cells crucial for normal health or functioning, this is also indicative of toxicity. An example is exposure to high levels of benzene leading to decreases in red blood cell counts. Such indicators of clear cut toxicity are known as biomarkers of adverse effect.

Ideally, biomarkers of effect can provide better measures of the toxic potential of trace chemcials than biomarkers of exposure since the mere presence of a substance (i.e., exposure) is not necessarily an indicator of toxicity. However, this ideal may not be achieved for a number of reasons. One problem in interpreting biomarkers of effect (or biomarkers of adverse effect) is that often more than one xenobiotic can result in the same effect. For example, the members of a whole class of compounds, the organophosphate pesticides, can cause alterations in the blood level of the same enzyme, cholinesterase. For another, a number of solvent chemicals can affect liver enzymes. In addition, it is possible that yet unidentified chemicals could cause these same effects. Thus, in the absence of other data such as measurements of levels in the environment, the biomarkers of effect are less specific than biomarkers of exposure in reflecting human exposures to trace levels of xenobiotics in the environment.

A number of studies have been performed in different countries and by international organizations to gain population-based data on biomarkers of exposure and, in some cases, effect. In the United States, the largest effort has been the National Health and Nutrition Examination Survey (NHANES), a continuous survey

which includes household interviews, a physical exam and blood analysis for a nationally representative sample of the non-institutionalized population.

C. Using monitoring of intake to estimate trace levels

Since it is difficult and expensive to undertake population-based studies of biomarkers of either exposure or effect, other techniques have been employed to provide indirect measures of trace levels of environmental xenobiotics. Perhaps one of the most comprehensive of these is the effort of the U.S. Food and Drug Administration (FDA) to estimate human intakes of selected pesticides, synthetic chemicals and mineral elements through the diet. This effort is referred to as the "Market Basket Survey" or the "Total Diet Studies". First conducted in 1961, the Market Basket Survey involves the retail purchase of foods considered to be representative of the "total diet" of the U.S. population. The survey includes analyses of 234 items that make up the diets of eight population groups of different ages and both sexes.

What are the trends in trace levels of environmental chemicals

A. Trends from food data

Data from the Market Basket Surveys for the years 1986-1991 have been used to provide a very good summary of the trends in the dietary intakes of nearly 120 compounds in a variety of population groups. These data clearly indicate that during this period the daily intake of selected pesticides and metals either remained stable or decreased. There was no indication of increasing human exposure to these substances through food. (2) (See Figure 1)

(INSERT FIGURE 1 HERE - It is the same as Figure 1 in the original trace chemical report - found on p. 10 of that report)

In addition, the 1986-91 analysis shows that daily intakes of the heavy metals lead, arsenic, cadmium and mercury were well below the provisional tolerable daily intakes during this period. Further, intakes of all pesticides analyzed were far below the acceptable daily intake (ADI) levels set by the World Health Organization and the United Nations Food and Agriculture Organization. (3) The levels of the pesticide with the highest intake, dieldrin, averaged about 1/30th of the ADI in the most highly exposed population - teenage and young adult males.

The levels of pesticide residues found in individual foods in the 1986-1991 Market Basket survey were much lower than the residue tolerances for raw agricultural products established by the U.S. Environmental Protection Agency (EPA). (4) This analysis also showed that levels of certain persistent pesticides in food have declined steadily since their use in agriculture was curtailed or eliminated.

The most recent data, for the year 2000, show that these persistent pesticides are found in only a small percentage of agricultural products and even in these cases at levels well below concentrations considered by governmental organizations to pose any risk. (5) Thus historical and recent data confirm that while humans are exposed to trace levels of chemicals in their food, these exposures occur only in a limited number of foods and at concentrations generally well below levels thought to be of concern. Thus, the presence of these chemicals in the food supply is not expected to pose a risk to human health.

B. Trends from human tissue and fluid analyses

The environmental chemical that has been studied most intensively in the United States during the past thirty years is undoubtedly lead and the biomarker in this case is blood lead levels in young children. These levels decreased dramatically from the late 1970s until the early 1990s and then more slowly during the past decade, The

most recent data, from NHANES, comparing information from 1991-1994 with that from 1999 shows that the blood lead levels in children decreased from a mean of 2.7 ug/dl to 2.0 ug/dl. These data are supported by state surveillance studies showing that the percentage of children with blood lead levels equal to or above 10 ug/dl decreased from 10.5% in 1996 to 7.6% in 1998. (6)

Another environmental chemical that has been studied in detail is DDT and the biomarker most often utilized is breast milk levels. Studies in Sweden spanning over thirty years documented a greater than 90% decrease in DDT breast milk levels between the late 1960s and the early 1990s. While the rate of decline has decreased in the last decade, it appears that DDT breast milk levels have declined by about 50% during this time. (7) Studies in Canada have shown a similar decline in DDT levels in breast milk. (8) (Figure 2) Data collected in many other countries also reflect a similar trend in DDT breast milk concentrations suggesting that these declines reflect worldwide phenomena. (9)

(INSERT FIGURE 2 HERE – It is the same as Figure 5 in Chapter 4 - on page 45 - of the report “Are Children More Vulnerable to Environmental Chemicals?”)

A third persistent chemical that has been studied extensively is dieldrin and the biomarker in this case is also breast milk levels. Data from Canada show about a 90% decline in dieldrin breast milk concentrations from the mid-1960s to the mid-1980s. (10-12) Similar measurements in Sweden, Denmark, Germany and Japan over the same time frame show the same result; about a 90% decline. (12, 13) These data again suggest that the trends are worldwide in nature.

In addition to these population-based studies, research has also been performed on sub-populations. Not surprisingly, levels tend to be higher and declines over time lower in sub-populations with continuing significant exposures. For example,

breast milk samples from women living in an area of Mexico where DDT is still in use for malaria control show much higher DDT levels than is found in breast milk from women in areas where this pesticide is not used. (14)

What can we learn from these trend data?

The population trend data provide very good indicators of the effects of actions that have been taken to reduce exposures to particular environmental chemicals. In the case of lead, when the blood lead level data from the 1970s to the early 1990s are compared to the levels of lead in gasoline it is clear that the two decline in unison and that the removal of lead from gasoline was the main contributor to the decline. One reason for the leveling off of the decline may be that other sources still persist and, indeed, lead in paint has been identified as the main remaining source. To the degree that the more recent declines reflect decreases in exposures to lead-containing paint future trends will likely reflect how successful current and future efforts are in minimizing this source.

In the cases of DDT and dieldrin, the dramatic decreases reflect the banning of the uses of these substances in many places and reductions in use in others. However, in distinction to lead, re-mobilization of these very persistent chemicals from the environment is probably a significant contributor to the flattening out of the decline curve currently observed. It is also the case that these chemicals are still in use in some places in the world so that the rate of decline of the body burdens of these compounds will probably continue to decrease.

The trends in sub-populations showing lower rates of decline generally reflect local conditions where sources still persist. In many cases, the sources are obvious; e.g., continuing use of large amounts of DDT or deteriorating dwellings containing lead paint flakes and lead-contaminated dust. In other cases, these anomalous rates of decline may point to previously undetected sources or to effects of unique

environmental circumstances that were not previously identified.

What is the human health significance of these trace levels?

A. Establishing links between environmental exposures and health effects

There are two lines of evidence that are used in establishing connections between exposures to environmental contaminants and human health effects. The first is based on toxicology data generated from studies on laboratory animals and the second is based on epidemiological studies of human populations - often in occupational situations.

A cornerstone of toxicological science is the ability to demonstrate a relationship between the dose (amount of exposure) of a given chemical and the response of the body following this exposure. Only if there is a dose-response relationship can it be concluded that the given chemical is responsible for the effects measured. For most chemicals, exposure to low doses of an agent will not lead to any observable effect; it is only when a threshold is reached that effects can be detected. These effects may or may not be adverse. For example, exposure to low levels of a chemical may mobilize the body's defenses to eliminate the compound from the body - clearly not an adverse effect. Exposure to higher levels of the same chemical may overwhelm this defense mechanism and the chemical may remain in the body rather than be eliminated and cause damage to one or another organ - clearly an adverse effect.

Laboratory animal toxicology studies are designed to elicit an adverse effect since the purpose is to determine how high a dose is required for such an effect to occur. Such studies are performed under special conditions, such as use of groups of animals that contain genetically uniform individuals and administration of exactly the same dose daily for a lifetime. These studies are generally the ones that are the bases

for regulatory levels set to protect human health. For regulatory purposes, the highest level at which no effect is observed or the lowest level at which an effect is observed is most often used as the starting point for setting a maximum acceptable exposure limit. Factors are applied to these levels to incorporate a significant margin of safety to account for uncertainties in applying controlled laboratory animal data to uncontrolled human environmental exposures. The use of these factors also reflects the fact that absolute safety cannot be achieved; there is no such thing as zero risk and the best that can be done is to limit exposures as much as possible based on the best available science.

A slightly different approach is applied to chemicals that are thought to cause cancer. For these agents, very high doses are administered to the laboratory animals so that the cancer will be detectable in the small number of animals that it is feasible to study in the laboratory. Generally, some percent of the animals in every dose group will have cancer so the approach described above for non-cancer causing chemicals (finding a no effect level) will not work. Instead, mathematical models are used to extrapolate the incidence of cancer at the high doses to what it might be at very low, possibly environmentally relevant doses.

Because of the great uncertainty in extrapolating from very high to very low doses, a large margin of safety is built into the extrapolation process when it is used for regulatory purposes. In addition, because some regulatory agencies assume that no level of exposure is absolutely safe, some acceptable incidence of cancer has to be established to set quantitative exposure limits. Generally, this is in the range of one in ten thousand to one in one million additional cancer cases. This approach often overstates the risk since it is known that for some carcinogens there is a threshold below which cancer will not occur. Many of the trace chemicals discussed here, such as DDT, appear to be threshold carcinogens so it is not surprising that increased cancer incidence has not been detected in environmentally exposed populations.

Epidemiological data are collected to see if a correlation can be established between human exposures and adverse health effects. This is generally very difficult when dealing with environmental exposures because each individual is exposed to differing amounts of a large number of agents on a daily basis making it very difficult to establish a connection between just one of these and an adverse effect. Most of the epidemiological data that are used in assessing the dangers of environmental chemicals are based on occupational studies since exposures to worker populations are much more regular, much higher than environmental exposures and direct exposure measurements over a significant period of time are often available.

Even so, because a range of worker exposures is generally not available, it is most often impossible to establish a quantitative dose-response relationship from such epidemiological data. Rather, occupational epidemiological studies are used qualitatively to suggest controlled laboratory studies that should be performed or to support the results of laboratory studies that have already been performed.

Recent research suggests that assessing the risk from trace elements in human tissues and fluids is even more complex than the above analysis indicates. These studies reveal the existence of “hormesis”, a dose response relationship which includes cases where a chemical may cause beneficial effects at very low doses as well as adverse effects at high ones. Hormesis has been recognized for a long time with respect to essential nutrients, such as vitamins A and D, that are necessary for good health at low doses but cause toxic effects when levels are too high. However, it is not clear if this phenomenon also applies to the environmental contaminants of most concern. It is clear that if this is the case, it will require a re-evaluation of the risks (vs. possible benefits) from the presence of low levels of trace substances in humans.

Another new field of research that might provide additional insights into human responses to xenobiotics is toxicogenomics. This is the study of the ways in which genetic differences affect individual responses to foreign chemicals. While this research

may provide a way to more accurately predict individual responses, it does not alter the well-established fact that human responses vary due not only to genetic differences, but also due to other factors (e.g., age and general health status). This variability has been taken into account in the safety factors that have been used to establish acceptable levels of exposure to environmental contaminants. Thus, whatever the outcome of toxicogenomics research will probably not affect the conclusion that trace levels of environmental contaminants are unlikely to have a public health impact.

B. Applying these approaches to trace chemicals

In general, the toxicological studies described previously (i.e., those performed on laboratory animals) are used to estimate an acceptable daily intake; that is, the maximum amount of daily exposure to an agent that is thought to be without harm and that includes a margin of safety. This value, in turn, is the basis for calculation of the maximum acceptable amounts of the agent in air, water, food, etc. The relationship between exposure and levels in body tissues and fluids is a complex one. Thus, it is difficult to estimate the latter from the former, and so regulators have not set acceptable limits for fluid and tissue levels of most environmental contaminants.

However, breast milk is a special case in that the milk is a food for the infant. Thus, as with other ingested substances, an acceptable concentration in food can be calculated based on the acceptable daily intake value. The World Health Organization has set acceptable intake values for persistent chemicals, such as DDT and dieldrin, and acceptable breast milk levels can be calculated based on these. Comparing these acceptable levels with those measured in populations worldwide, it is clear that DDT and dieldrin concentrations in breast milk are much lower than the acceptable values and have been for some time. As noted before, it is possible that there are individuals in less developed countries who may be highly exposed and for whom acceptable levels may be exceeded.

Lead represents another special case. While there is scientific dispute about the "safe" level of lead, the U.S. Centers for Disease Control considers blood lead levels of over 10 ug/dl as elevated and thus of concern. As the data presented indicate, the average blood lead levels are now about 2 ug/dl. This represents a dramatic decline during the last quarter of the 20th century, a decline that had clear benefits to children's health as the higher levels were clearly linked to adverse effects. (See the ACSH publication: "Lead and Health : An Update, 2001)

However, the exposure data also show that currently a small, but significant percentage of children, have elevated blood lead levels and are thus at increased risk of adverse effects. Thus, these data suggest that while lead exposure is not a general problem, there are populations of children who have blood lead levels that are of concern.

As indicated earlier, advances in analytical techniques have made it possible to detect smaller and smaller amounts of trace contaminants in human fluids and tissues. The presence of such substances is not equivalent to toxicity from these agents. Even for DDT and dieldrin, substances that were applied in large amounts in and around individuals for many years, current levels in the advanced world are much too low to be of concern. Trace levels of other substances which have resulted in even lower human exposures are similarly too low to be of concern.

While acceptable daily intakes used to evaluate the risks from environmental chemicals are almost always derived by applying a margin of safety to the results of laboratory animal studies, epidemiological evidence also can assist in assessing the risks from trace contaminants. Since cancer is commonly the toxic effect of most concern, especially for organic chemicals such as dioxins, DDT and dieldrin, it is instructive to examine cancer incidence as trace levels of these chemicals in humans first rose and then declined precipitously. What is seen is that the incidence of most cancers has remained essentially the same with the exception of lung cancer where the

incidence changed in response to tobacco consumption patterns. Thus cancer incidence data do not provide any support for a connection between trace levels of environmental contaminants and that human disease.

While there have been occasional reports questioning this conclusion, further study has not borne out claims of a connection. For example, some epidemiological studies in the early 90s claimed to show an association between cancer, particularly breast cancer, and levels of organochlorine compounds, mainly DDT and PCBs, in human tissues and fluids. The resulting public concern spurred further work including a very well publicized large scale study of women living on Long Island where the incidence of breast cancer is above average. Careful evaluation of the outcomes of about 30 epidemiological studies on organochlorines and breast cancer (15), as well as the recently published results of the Long Island research (16) reveals that no association between organochlorine compounds and elevated rates of breast cancer could be established.

With regards to possible adverse effects of the levels of trace metals in humans, epidemiological data do not reflect any change in the incidence in neurobiological effects in children or adults associated with the very significant decreases in blood lead levels and levels of mercury in human food. This suggests that any effects of this type were small or limited to a small sector of the population even when exposures were high and are unlikely to be detectable now in the general population considering the large decreases in these trace levels of metal elements and compounds that has occurred.

Summary and Conclusions

The continuing detection of synthetic chemicals in human tissues and fluids has led to legitimate concern about the possible health effects of the presence of such chemicals in the human body. To evaluate this concern, it is important to understand

how these chemicals are detected, what the trends are in the levels of such compounds and what is known about the health impacts of the levels that have been detected.

Advances in analytical capabilities has made it possible to detect lower and lower levels of these contaminants in humans so that new compounds are identified regularly and older compounds continue to be detected even when levels decline drastically. The significance of these detections can only be understood by looking at how these levels have changed over time and how the concentrations compare to those considered capable of causing adverse health effects in humans.

Studies of contaminants in the food supply and direct measurements of human fluids and tissues reveal that the levels of contaminants of concern, such as lead and DDT, have declined more than 90% in the general populations during the past few decades. The declines appear to be continuing but at a slower rate. These studies also reveal that there are some special populations which continue to show high levels of contamination, generally because of local use of the chemical of concern.

Comparison of the current low levels with the lowest levels thought to be of concern by international and national regulatory agencies reveals that the trace amounts in humans are well below these levels of concern for the general public. Thus, efforts to further decrease these levels will not improve public health; instead efforts should focus on those populations that still experience high exposures.

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